Sixth Southwest Hydrometeorology Symposium
Tempe, AZ
September 27-28, 2011

Tuesday September 27, 2011
Climate Services:

DeWayne Cecil. NOAA Western Region Climate Services Director. *NOAA's Climate Services.*

Kelly Redmond. Western Region Climate Center. *Climate Services – a regional perspective*.

Zack Guido. Climate Assessment for the Southwest (CLIMAS). *Climate Services: A CLIMAS Perspective.*

To help build the nation's capacity to prepare for and adapt to climate variability and change, the Regionally Integrated Sciences and Assessments (RISA) program was established by NOAA in the mid-1990s and charged with working in close partnership with end users to develop and provide cutting-edge scientific information. RISA teams, which cover 11 distinct geographic regions including the Southwest, bridge the gulf between research and service and play a vital role in satisfying the burgeoning demand for regional, timely, and credible climate services.

The Climate Assessment for the Southwest (CLIMAS)—the RISA dedicated to Arizona and New Mexico—provides climate services that range in the effort and resources they require, from quasi-operational products (long-term) to rapid data analysis (short-term). In recent years, the core component of CLIMAS has been dedicated to satisfying climate services that fall in the middle of this time spectrum, services that take several to many months to complete.

This presentation discusses climate service activities of CLIMAS within the broader RISA context, focusing on the recent development and evaluation of the La Niña Drought Tracker. The Tracker was a pithy e-publication that informed the region of current and projected drought conditions during a strong La Niña event—La Niña conditions historically deliver dry conditions to the region. The goals of The Tracker were to aid resource management decisions and improve climate understanding. Insights gleaned from the evaluation of The Tracker, as well as other experiences, suggest that medium-term climate services are vital to satisfying stakeholder demand, creating new and strengthening existing partnerships, aiding decisions, and advancing climate literacy—main tenets of a climate service program. However, they are not without challenges. They require substantial commitments in resources (time and money) and expertise that often do not generate financial returns (i.e. leverage funding), are difficult to predict and plan for, and create limited opportunities for publications. As a result of these challenges, medium-term climate service providers need to have an organizational framework that enables rapid responses to stakeholder requests.

Nancy Selover. Arizona State Climate Office. *Climate Services: A State Climatologist Perspective.*

James Buizer. University of Arizona. *Climate Services & University Research (?)*.

Anthony Cox. AZ Department of Emergency Management. *Information needs for planning and relief).*

Ben Davis. Maricopa County Air Quality. *Monitors and alerts*.

Panel Discussion: Cecil, Buizer, Redmond, Guido, Selover, Cox, Davis

<u>Coffee Break</u>

John Brost, Glen Sampson, Ken Drozd, Erin Boyle, and Ryan Fliehman. National Weather Service – Tucson. *From Fires to Floods: How the National Weather Service in Tucson Increased Flash Flood Awareness after a Historic Wildfire Season.*

Historic wildfires burned across southeast Arizona drawing national media attention in June 2011. The Horseshoe 2 and Monument fires destroyed or damaged over 80 residences, businesses and other structures. Additionally these fires modified soil conditions such that flash flood occurrence and severity could be magnified by over an order of magnitude. Thus any post-wildfire flash flooding and debris flows that occur may cause damage more devastating than the fires.

Southeast Arizona rapidly transitioned from the spring drought conditions to the wet summer Monsoon season by the first week of July. The Monsoon season is characterized by frequent thunderstorm activity (almost daily over the mountains), severe convection, heavy rainfall and flash flooding. The National Weather Service (NWS) recognized the immediate need to raise awareness of the increased potential for flash flooding and debris flows in the burned areas. Within a few days of the Monument fire becoming contained, heavy rainfall caused a flash flood which damaged multiple homes, closed major roads, caused a debris flow and re-sculptured the water channels.

This presentation will discuss the following points:

- How the level of awareness for flash floods was raised in a very short amount of time within the affected communities
- The educational materials used to heighten awareness
- The use of emerging technologies, social media applications and multiple interactions with various public agencies to help disseminate this information.
- The use of (commercial) portable weather stations to collect vital rainfall data from the burned areas
- And a brief case study of a flash flood and debris flow which took place the day after the portable weather station was installed.

Casey C. Kahn-Thornbrugh, Stephen W. Bieda III, Andrew C. Comrie, Michael A. Crimmins, and John J. Brost. University of Arizona. *Forecasting the 2011 North American Monsoon Onset and Precipitation for southern Arizona: A Case-study in Applied Climatology.*

Severe to exceptional spring drought and early summer wildfire conditions of 2011 presented Arizona stakeholders with many challenges and left many asking if the 2011 North American

Monsoon Season (NAMS) would help mitigate these conditions. Given the latest research and understanding of the NAMS, a precipitation outlook for June-September (JJAS) was put together for southern Arizona utilizing the following variables: (1) spring precipitation anomalies in northern México, (2) spring sea surface temperature (SST) anomalies in the tropical and northern Pacific, including the state of the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO), (3) the state of Atlantic SSTs and the Atlantic Multidecadal Oscillation (AMO), and (4) the early summer alignment of the "monsoon ridge" over the U.S. and México. Our results showed that the conditions of these variables for the spring and early summer 2011 were consistent with those of years 1951, 1962, 1963, 1967, 1999, and 2008. Based on the NAMS onset and precipitation for these analog years, our forecast called for an average-to-slightly early onset of NAMS precipitation in the Tucson area, and for July precipitation to be between 75-120% of the 1971-2000 average. Verification of our forecast showed the onset date for NAMS precipitation occurred in Tucson on July 3rd. In addition, July precipitation measured at the Tucson International Airport was 79% of the 1971-2000 average (73% of the 1981-2010 average). Verification of our forecast will continue for the duration of NAMS 2011, for the remaining months of August and September.

Melissa Wagner, Randy S. Cerveny, and Soe W. Myint. Arizona State University. *Geospatial Analysis of Reconstruction Rates Following a Tornado Disaster.*

Remote sensing has demonstrated to be an instrumental tool in monitoring land changes as a result of anthropogenic change or natural disasters. Most geospatial research has focused on small-scale disasters, while the few tornado studies have provided only damage assessment perspective. This study examines reconstruction following the 1999 Moore, Oklahoma tornado across three consecutive years utilizing medium resolution imagery and a series of image processing algorithms. Spectral enhancements including NDVI, SAVI, UI, and two new indices, Shortwave Radiation Index, SWIRI, and Coupled Vegetation and Urban Index, CVUI, were utilized in conjunction with a recovery index and statistical thresholds to assess reconstruction. Classification accuracy assessments prove that geospatial techniques and medium resolution imagery can capture recovery rates with the most effective results noted with SWIRI using the 1.5 standard deviation threshold. Computed annual and Fujita Scale recovery rates indicate that (a) the most severely damaged areas associated with an F5 rating were the slowest to recover, while the lesser damaged areas (F1-F3) were the quickest to rebuild, and (b) complete recovery was never attained even three years after the event regardless of F-scale damage zones. With these results, decision makers and other policyholders could implement more resilient approaches in reconstructing the more severely damaged areas.

Matthew Pace, Kimberly DeBiasse and Randall Cerveny. Arizona State University. *Defining the North American Monsoon using Climatological Isentropic Analysis*.

Forecasting precipitation across the southwestern United States during the North American Monsoon (NAM) has been a long standing topic of research. While numerous studies have focused on synoptic scale analysis using constant pressure charts, only a few and dated studies have examined forecasting precipitation during the NAM using isentropic analysis (constant potential temperature surfaces). Within this research, the use of isentropic analysis, as a synoptic climatology forecast tool, was examined to determine its ability to forecast precipitation within

Arizona during the NAM. Arizona climate division rainfall data, acquired by the National Climatic Data Center, were used to determine the ten most extreme driest and wettest monsoon seasons for Arizona, from the time period of 1959 through 2009. For these top events, average 310K and 315K isentropic and mixing ratio maps were created for analysis. Those years with below normal precipitation, the isentropic trough is shifted eastward and orientated along a southwest to northeast axis. Subsequently, moisture is shifted east of Arizona resulting in below normal precipitation. During years with above normal precipitation, a broader and deeper isentropic trough is present across the entire southwestern United States, with a north to south axis of orientation. This shift and orientation result in an influx of deep monsoonal moisture into Arizona from the south, resulting in above normal precipitation. It appears as if the orientation and depth of the isentropic trough during the NAM can accurately represent uplift/flow of moisture resulting in enhanced or decreased precipitation across Arizona.

Christopher L. Castro, Hsin-I Chang, Francina Dominguez, and Carlos Carrillo. University of Arizona. *Can a regional climate model improve the ability to forecast the North American Monsoon*

Global climate models are quite challenged to represent the North American monsoon, in terms of its climatology and interannual variability. To investigate the question of whether a regional atmospheric model can improve warm season forecasts in North America, a retrospective Climate Forecast System (CFS) model reforecast (1982-2000) and the corresponding NCEP-NCAR Reanalysis have been dynamically downscaled with the Weather Research and Forecasting (WRF) model for a domain over the contiguous U.S. and Mexico, with similar parameterization options as used for high-resolution numerical weather prediction and a spectral nudging capability. The regional model dramatically improves the climatological representation of monsoon precipitation due to its more realistic representation of the diurnal cycle of convection. However, it is challenged to capture organized, propagating convection at a distance from terrain, regardless of the boundary forcing data used. Dynamical downscaling of CFS generally yields modest improvement in surface temperature and precipitation anomaly correlations in those regions where it is already positive in the global model. There are also marked differences in potential seasonal predictability from early to late summer. CFS has a relatively greater ability to represent the large-scale atmospheric circulation in early summer due to the influence of Pacific SST forcing, and therefore surface temperature and precipitation anomaly correlations are highest at this time. As the dominant modes of early warm season precipitation are better represented in the regional model, provided reasonable large-scale atmospheric forcing, dynamical downscaling will add value to warm season seasonal forecasts. CFS performance appears to be inconsistent in this regard.

Carlos Carillo, Hsin-I Chang, Christopher L. Castro, Francina Dominguez, and Erick Rivera. University of Arizona. *Evaluation of value added using dynamically downscaled GCM product for WRF historical and future climate projection.*

Future water resource planning is an important topic for Southwest U.S. and Mexico. There are large uncertainties in current warm season climate change projection and seasonal forecast. During the warm season, terrain-forced monsoon thunderstorms are the dominant source of precipitation and the timing of monsoon onset influences water availability. To assess the large-

scale projections for future climate, most water resource providers in Western U.S. rely on statistical downscaled projections derived directly from the Intergovernmental Panel on Climate Change (IPCC) global climate models (GCMs). IPCC global model projections are in agreement that future temperature will increase but they generally have a poor precipitation representation in the Southwest U.S. Therefore, the future projections in this respect are not reliable.
Of greatest current interest for water resource planning is the climate change projection in the coming 20-30 year timeframe. Since the data from global climate models is inadequate for water resource projection, our approach is to dynamically downscale the GCM data, and create finer spatial and temporal resolution information using a RCM. We use the Weather Research and Forecasting (WRF) model to dynamically downscale two well performing GCMs from IPCC A2 emission scenario (HADcm3 and MPI-ECHAM5) for historical and climate projection simulations in Southwest U.S. and Mexico. The main goal is to first evaluate the performance of the dynamical downscaled RCMs for historical period and form a baseline for analyzing the North American Monsoon projection in the early 21st century. Some preliminary results from climate change projection period will also be shown.

<u>Drought:</u>

Dan Griffin – University of Arizona. *The tree ring record of drought in the Southwest.*

Water management and decision-making are typically based on gauge records of streamflow and precipitation. However, gauge records rarely began before the 20th century and this limited period may not represent the full range of long-term hydrologic variability. Fortunately, the Southwest has a dense network of moisture-sensitive tree-ring chronologies. These records, which extend back centuries to millennia, are invaluable for providing long-term perspective on the hydroclimatic variability witnessed during the instrumental era.

For example, Colorado River flow at Lee's Ferry has been carefully reconstructed for the water years 762-2005. The reconstruction points to extreme drought events in the 9th, 12th, and 16th centuries that were more severe and sustained than any during the instrumental era. This study also suggests that the early 20th century was among the wettest periods in 1,244 years. For purposes of long-term drought planning and hydrologic modeling, this tree-ring estimate provides a sequence of flow events that is more rich than the instrumental record alone.

Emerging tree-ring research is focused on summer monsoon rainfall variability and its relationship to cool-season climate in the Southwest. The first reconstruction of monsoon precipitation for the Arizona-Sonora region extends from 1539-2008, and points to a period of dry monsoons in the late 19th century that was more persistent than any during the instrumental era. Comparison with a complimentary reconstruction of winter-spring precipitation indicates that with some lead or lag, persistent monsoon drought often coincided with cool-season drought periods, including the 16th century "Megadrought," the 17th century "Puebloan drought," and the ongoing 21st century drought. This research highlights the importance of precipitation seasonality in the Southwest and provides the first tree-ring perspective on pre-instrumental monsoon variability for the region.

Laura M. Edwards, Mark Svoboda, Brian Fuchs, Matt Rosecrans, David Miskus, Rich Tinker, Anthony Artusa, Brad Rippey, Eric Luebehusen, Mike Brewer, Richard Heim. Western Region Climate Center. *The U.S. Drought Monitor: An Author's Perspective*.

The United States Drought Monitor (USDM) has evolved from a small group of collaborators hand-drawing areas of drought on a map, to an internationally recognized inter-agency process model for climate and drought monitoring. The technical aspects of producing such a map and narrative have made great strides since the experimental product launched in 1999. Authors and participants have changed, along with the number of participants in the weekly discussion rising dramatically to over 300 listserv subscribers. The impacts of the map are increasing and have become significant in many regional, state and local communities. But the basics remain, and the core mission of the eleven current authors is to depict, as accurately as possible, areas and severity of drought across the U.S. The core process of utilizing objective climate information in combination with impact reports from the field remains unchanged. The weekly process of developing each map and narrative will be described from an author's perspective, as well as how interested parties can take part in the USDM discussion.

Nancy Selover. State Climate Office. Governor's Drought Task Force – Technical Monitoring Committee. *Determining drought status in Arizona, weekly, monthly, seasonally*.

Mike Crimmins. University of Arizona. *AZ DroughtWatch – Arizona impacts reporting.*

Kathy Chavez. Pima County LDIG representative. *Local drought impacts monitoring*.

Susan Craig. Arizona Department of Water Resources. *ADWR's Drought Planning Efforts.*

Ms. Craig's presentation will cover drought planning efforts taking place at ADWR. Information will be provided on the *Arizona Drought Preparedness Plan*, which provided the framework for the development of the state's drought program, and ADWR's role in the drought declaration process. Drought planning requirements for water providers will be addressed, as well as utilization of the information from a state planning perspective. Impacts to the program resulting from the changes realized in the state budget will also be discussed. Lastly, Ms. Craig will talk about plans for the future, including assistance to water providers and areas of the state with vulnerability due to drought.

Patrick Bray. Arizona Cattleman's Association.

Dan Bunk United States Bureau of Reclamation. *Colorado River Drought: River Operations in the Lower Colorado Region.*

The period from water year 2000 to 2011, inclusive, has been the third driest over the Colorado River Basin since 1906, with the period from 2000 to 2004 being the lowest 5-year period on record. During this time, the combined contents of Lake Powell and Lake Mead—the two largest reservoirs on the Colorado River combining for greater than 80 percent of the system storage capacity—decreased from approximately 95 percent of capacity at the end of water year 1999 to approximately 46 percent of capacity by the end of water year 2004. The severity and duration of this drought and its resulting impacts on Colorado River reservoir operations prompted the U.S. Bureau of Reclamation (Reclamation), along with the seven Colorado River Basin States (Basin States) and other interested stakeholders, to develop and implement the Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead (2007 Interim Guidelines). The 2007 Interim Guidelines provide a prescriptive methodology for the coordinated operations of Lake Powell and Lake Mead at all reservoir levels, outlines shortage criteria for the Lower Division States (Arizona, California, and Nevada), and promotes water conservation and more efficient water use in the Lower Colorado River Basin through its Intentionally Created Surplus procedures. Reclamation's mid-term operations model is a deterministic hydrologic model that utilizes forecasted unregulated inflows developed by Colorado Basin River Forecast Center (CBRFC) in Salt Lake City, Utah, to project 24 months of future reservoir conditions. To help Reclamation and Colorado River stakeholders better understand the operational uncertainties and manage risk associated with drought and a changing climate, a probabilistic mid-term operations model, which utilizes an ensemble of forecasted inflows developed by the CBRFC to predict a range of possible reservoir conditions, is currently being developed. In addition, Reclamation, in collaboration with the Basin States and other interested stakeholders, is currently developing the Colorado River Basin Water Supply and Demand Study. This study will characterize current and future water supply and demand imbalances in the basin and assess risks to basin resources, as well as identify and analyze adaptation and mitigation strategies to help resolve those imbalances.

John F. Henz. Dewberry & Davis. *Return to the Valley: On the Evolution of the Flood Control District of Maricopa County's Meteorological Services Program*.

In 1996 and 1997 the Flood Control District of Maricopa County funded the Meteorological Services Pilot Program to test the viability of a flash flood prediction program to supplement the National Weather Service's forecast services. The supplemental services include specific forecasts for the District's flood response plans, basin specific quantitative precipitation forecasts and specialized services for the emergency response community. The pilot program was designed and supported for two years by Henz Meteorological Services. Afterwards, a competitive bid resulted in the selection of another weather service for the Meteorological Services Program (MSP) in 1998. Three years later the District decided to bring the MSP internal where it has resided since 2000. In 2011 one of the initial MSPP meteorologists, John Henz, was contracted to provide weather forecast support for the 2011 Monsoon Season to form a basis for comparing the 1996/97 MSPP and 2011 MSP.

This paper will review changes in the primary forecast tools, observational network and user support for the MSPP and the MSP. Significant advances in the observational network include the National Weather Service's WSR-88D Doppler radar network, National Weather Service/Salt River Project's seasonal sounding program, the expansion of the District's rain gage, stream gage and weather station networks and the availability of GPS-MET Integrated Precipitable Water(IPW) observations. Additionally, the joint NWS/University of Arizona's WRF-series regional models provide detailed precipitation and composite radar reflectivity forecasts to assist the local forecast process.

(?) Arizona Fish and Game. *Drought response for wildlife.*

Yazdanpanah, H., M Momenyk, and H. Dezfullian. University of Isfahan, Iran. *Drought monitoring using remote sensing and SPI in of south of Khuzestan province , Iran.*

In this study an attempt has been made to apply RS and GIS techniques for drought detection in the southwest of Iran. The drought phenomenon was determined based on Standardized Precipitation Index (SPI)using monthly precipitation. SPI values were interpolated to determine the spatial pattern of meteorological drought and threshold value for different types of drought. The Normalized Difference Vegetation Index (NDVI) was obtained by using surface reflectance with 250m resolution from MODIS satellite during 2002-2008.
The NDVI was correlated to the Standardized Precipitation Index (SPI), a multiple-time scale meteorological-drought index based on precipitation. The 6-month SPI was found to have the best correlation with the NDVI, indicating lag and cumulative effects of precipitation on vegetation, but the correlation between NDVI and SPI varies significantly between months. The highest correlations occurred between NDVI and 12 months SPI , and lower correlations were noted for 1 month SPI.

Coffee Break

Panel Discussion: Griffin, Edwards, Selover, Crimmins, Chavez, Craig, Bray, Bunk, Fish & Game.

5:00 pm - Reception
Posters:

Mike Hardiman. National Weather Service – El Paso. *Characterization of Daily Monsoon Activity Using GIS-Based MPE Data.*

A "Raininess Index for the Arizona Monsoon" was developed by Phoenix forecaster John TenHarkel in 1980. His index characterized daily monsoon activity based on the percentage of Arizona Cooperative Observer (COOP) Stations reporting measurable precipitation, essentially using COOP stations as a proxy for areal coverage of measurable precipitation. This index has been shown to accurately portray monsoon "bursts" and "breaks" in Arizona.
This poster presentation will apply a modern "twist" to TenHarkel's method, replacing COOP stations with areal coverage of Multi-sensor Precipitation Estimate (MPE) data, swapping Arizona for southern New Mexico and Far West Texas, and applied over June-September 2010 and part of 2011. The main region of study will be broken up into several sub-regions, primarily based on topography. The sub-regions are expected to help further characterize daily monsoon activity - for example, delineating between days with widespread high-elevation rainfall and little lowland rainfall, days with widespread rainfall at all elevations, days with better precipitation coverage over western areas vs. eastern, etc.
Depending on the results, it is hoped that this method will be used as a first step for future studies, grouping common days and exploring synoptic patterns, the presence and location of upper-tropospheric "inverted" troughs and Mesoscale Convective Vortices, and low-level moisture surges, with an attempt to increase the understanding of the role of the features with

respect to Monsoon precipitation coverage, and improve Probability of Precipitation forecasts over the El Paso/Santa Teresa forecast area.

Matt Switanek. University of Arizona. *Changes in Decadal Prediction Skill for Colorado River Streamflow Using Observed and Reconstructed Ocean-Atmosphere Teleconnections.*
Water Resources

The Atlantic Multidecadal Oscillation (AMO) and Pacific Decadal Oscillation (PDO) time series are used to forecast decadal streamflow in the upper Colorado River at Lee's Ferry. In the instrumental record, we obtain unusually high decadal forecast skill that is statistically significant at the 97% confidence level. The retrospective forecast skill in the instrumental record is then compared to the skills obtained using the available ocean-atmosphere teleconnection and streamflow reconstructions derived from tree rings. We find much lower skill in the reconstructed record. Using frequency analysis, we show that the streamflow and sea surface temperature oscillations in the instrumental records all have dominant low frequency periodicities (> 35 years) that explain much of the total variance. However, such dominant periodicities do not appear in the power spectra of the reconstructed records of AMO, PDO and streamflow. Given that these dominant low periodicities are likely responsible for the high prediction skill in the instrumental record, it remains uncertain whether reliable decadal streamflow predictions in the upper Colorado River basin will be possible in the years ahead.

Melissa Wagner (Arizona State University) and David Blanchard (NWS Flagstaff). *Geospatial Verification of the October 6, 2010 Tornado Event*.

Hazard research has recognized remote sensing methodologies as powerful tools in damage assessment as a result of ubiquitous coverage, regular data collection and repeatable independent analyses. Through the manipulation of multispectral data, damaged areas can be detected by changes in spectral signatures of ground features. This paper examines remote sensing as a means to analyze tornadic damage paths of the October 6, 2010 Flagstaff tornado event. Tornado tracks discerned from Landsat TM and ETM+ 30 meter resolution imagery are compared with WSR-88D radar tornado rotational track data. This research demonstrates the utility of remote sensing methodologies of tornadic events from a meteorological perspective. Remote sensing not only supplements damage assessments especially in remote regions, but can also be used to cross validate tornadic signatures observed by radar and damage class from ground surveys. By comparing rotational tracks with damage paths discerned from satellite imagery, issues of terrain are revealed with the more uniform approach.

Fernanda De La Cerda and Vanessa L. Lougheed. University of Texas, El Paso TX. *Influence of orography on the weather patterns and water availability of a topographically complex Chihuahuan desert.*

Arid and semi-arid ecosystems cover a large extent of the planet's land surface and are highly susceptible to/and dependent on resource availability patterns, especially precipitation. Topography affects large scale weather patterns and redistributes precipitation which creates a variety of microclimates in complex landscapes; how these patterns are modified, however, is still not fully understood. Climate change models for arid and semi-arid ecosystems predict a change towards more extreme precipitation events; understanding the mechanisms involved in redistributing precipitation is crucial for the protection of these areas. Indio Mountains Research Station (IMRS) is located in the northern Chihuahuan Desert and seems to exhibit the characteristics of a rainshadow area when comparing its weather to that of surrounding towns. We compared data collected from weather stations at IMRS Headquarters, six permanent or ephemeral water bodies throughout the IMRS property, and publically available data for El Paso, Pecos, Sierra Blanca, and Marfa, TX. Detailed water level data and soil cores were collected from the IMRS water bodies, as well as regional topography and hydrology ArcGIS layers. These data was used to better understand the relationship between large scale weather patterns, topography, soil particle size distribution, size and frequency of rain events, and water availability at IMRS ponds. Contrary to our predictions, IMRS does not receive significantly lower precipitation than surrounding sites, but exhibits lower wind speeds and higher average temperatures; this indicates more of an orographic than rainshadow effect of topography on the area. Temperature patterns inside IMRS were affected by elevation and aspect of each individual site, with cooler sites being at higher elevations and further to the east; also, sites on west facing slopes were warmer than expected. Elevation and orientation of each site with regards to the surrounding landscape also influenced precipitation patterns, with the drier sites being at lower and more southerly locations. Water availability at the ponds was dependent on each pond's morphology, location, soil particle size distribution, and precipitation. Ponds that received more precipitation and had higher proportion of clay in the soil also held water longer; each pond's morphology and location influenced the hydrology of the pond.

Wednesday September 28, 2011
Water Resources:

Gary Carter. NOAA/NWS Office of Hydrologic Development. . *Working together to address the Nation's water resources challenges.*

Kevin Werner. Colorado Basin River Forecast Center. *CBRFC Operations.*

James Holway. Central Arizona Water Conservation District. *Arizona water issues.*

Dino De Simone. Natural Resources Conservation Service. *Snow Surveys in the West.*

Jonathan Skindlov. Salt River Project. *Reservoir Operations and Water Supply Planning at Salt River Project.*

Steve Waters. Flood Control District of Maricopa County. *A classification index for precipitation events in Maricopa County, AZ.*

A new classification index has been developed to describe the severity of storms on a 1-10 scale. Inputs to the index include the area covered by the storm, the average rainfall amount over that area, and the storm duration. Intensity and return frequency were intentionally discarded because these are hard concepts for the layman to grasp. A decision was made at the outset to emulate the rating of the *Richter Scale* as used for earthquakes –where a 5 is noticed but does little damage, a 7 causes significant damage and a 9 is catastrophic and rarely experienced. The method's application ranges from historic storms above stream measurement points, to comparisons over given geographic areas, to forecasting using QPF values as input. It is easy for someone with a science background to use, gives nearly identical results no matter the qualified user, and is fairly automated using commonly available software.

Speaker's Biography: I currently serve as a Senior Hydrologist and the Flood Warning Branch manager for the Flood Control District of Maricopa County, where my duties include supervision of flood warning, hydrologic data collection and publishing, web site content management and coordination of emergency response for the District. I have worked for the District for 21 years, and previously worked for the City of Tucson for 3 years as an engineering intern. I received a BS degree in Hydrology and Water Resources from the University of Arizona College of Engineering and Mines in 1988. I am a past Membership Chair and Webmaster for the Arizona Floodplain Management Association, a member of the Arizona Statewide Flood Warning System Task Force, an elected member of the American Meteorological Society, and a past Board member of the National Hydrologic Warning Council.

Panel Discussion: Carter, Werner, Holway, DeSimone,. Ester, Waters.

Coffee Break

Carlos Manuel Minjarez Sosa, Kenneth Cummins, Christopher Castro, Phillip Krider, and Julio Waissman. University of Arizona. *Improved Quantitative Precipitation Estimation During the North American Monsoon Using Cloud-to-Ground Lightning*.

In the western United States, accurate quantitative precipitation estimation (QPE) is important for both water resource projection and forecasting flash floods.
Over the last decade new datasets have been developed combining typical techniques to estimate and measure precipitation (radar and rain gauges). Given the relationship between cloud-to-ground lightning events and convective precipitation, lightning may provide a viable alternative for QPE in regions of poor sensor coverage.
This study is focused in Southern Arizona, in the vicinity of the KEMX Tucson NEXRAD site during the North American Monsoon. It is well know that the radar terrain blockage and the lack of in- situ gauge observations is a common problem in this region, therefore this region is representative of the QPE estimation problem over the entire western U.S. The datasets used are National Mosaic and Multisensor QPE (NMQ) and lightning data from the National Lightning Detection Network (NLDN) for several recent monsoons.
We test and evaluate two linear stationary models. The first model is resolved with typical least square, using gridded lightning events and gridded precipitation in all domain as an input and output respectively. On the other hand, a gridded (8Km) multi-model was explored. In this second approach the precipitation of each grid is estimated using a local models based on actual and past lightning events of the grid and its vicinity. Finally, based in this model, a non-stationary approach was applied based on Kalman filters. By superimposing the lightning-derived QPE on the radar-derived QPE in areas of poor sensor coverage, a much clearer picture of convective development (in areas of complex terrain) emerges. The amalgamated QPE product, that reflects both radar and lightning-derived precipitation we are developing, could be

eventually used operationally in real-time for any radar site that experiences convective precipitation in complex terrain.

Kevin W. Murphy, Andrew W. Ellis. Arizona Sate University. *An assessment of stationarity of climate and runoff in watersheds of the Colorado River Basin*.

John F. Henz. Dewberry & Davis. *On The Use of Radar-based Design Storms for Floodplain Delineation and Dam/Flood Retarding Structures Studies.*

Over the past eighteen years the National Weather Service has installed a national network of WSR-88D Doppler radars. In Arizona this network includes radars near Flagstaff, Phoenix, Tucson and Yuma. The nearly continuous sampling of precipitation systems year-round provides a significant opportunity to update and upgrade the design storms used for floodplain delineation studies and the rehabilitation of dams and flood retarding structures or levees. Typically the design storms used for these studies are based on a set of rainfall frequency and areal reduction factors developed from data sets of rain gages and stream gages which may or may not be representative of the basin being modeled.

Radar presents the opportunity to sample the observed precipitation coverage and temporal distribution of the entire spectrum of storms from isolated thunderstorms to monsoon storm systems to sub-tropical disturbances to large general winter storms. Radar samples roughly half mile by half miles areas with temporal resolution of roughly every 5-minutes. Examples of 2-y to 500-yr design storms will be presented from the FEMA-approved South Boulder Creek Floodplain delineation study in Colorado and from PMP studies in Colorado, New Mexico and Arizona. The time has come for this NWS resource to become a standard for design storm development.

John F. Henz. Dewberry & Davis. *High Impact Weather Events –A Challenge for Hazard Mitigation Plans and Flood Response Plans.*

High impact weather events are defined as hurricanes, tornadoes, hail, high winds, droughts, floods and flash floods and severe general storms. Recent examples of these events include the Atlanta floods of 2009, the May Day 2010 severe flash flood and tornado assault on Memphis, Tennessee and the concurrent flash flooding of central Tennessee and Kentucky and the April 26/27, 2011 concurrent tornado and flooding events . The flash flooding and tornado events in northern Arizona in October 2010 preceded the major tornado, high winds and flooding of October 26-27, 2010 as "a meteorological bomb" storm developed over the northern Mid-West and then traversed the country. Less than one year later the epic spring snowmelt flooding in the Central United States produced significant flooding along the Mississippi River. As the flood head reached the South, its arrival coincided with the deadly April 27, 2011 tornado outbreak.

The hallmark of these high impact weather events is that concurrent severe weather events occurred with severe or major riverine flooding. Most hazard mitigation and flood response plans focus on the singular occurrence of different forms of high impact weather not the concurrent occurrence of several forms of events. This paper will evaluate the timing and types of severe weather events that concurrently occurred and produced a high stress on the emergency management community.

Erick R. Rivera, Francina Dominguez, Christopher Castro, and Dennis Lettenmaier. University of Arizona. *Future changes in precipitation estimates for the Western United States under a warmer climate as simulated by regional climate models.*

Climate change is expected to modify the frequency and intensity of extreme precipitation events, including intense rainfall events and dry spells, in the Northern Hemisphere. In this work, we use projections from eight regional climate models (RCMs) driven by IPCC AR4 global climate models (GCMs) in order to investigate the potential changes in the intensity and frequency of future extreme precipitation events over the western United States at the spatial scale required by local decision makers. Seven of these are derived from the North American Regional Climate Change Assessment Program (NARCCAP) and one additional simulation was produced independently at the University of Arizona. We define extreme precipitation in terms of return periods using traditional Generalized Extreme Value (GEV) theory and "peaks-over-threshold" statistical techniques.

Tim Brice. National Weather Service – El Paso, TX. *Using Google Earth in Flood Operations.*

In the last five years, Google Earth has changed how we view our planet. It has provided an easy to use platform for exploring the earth utilizing many and varied compatible data sets. For this presentation, I will touch on several ways to use Google Earth to get to know your flood prone areas, to help detect and react to flash floods and to use Google Earth as a post flood analysis tool. Many related web links and data resources will be discussed to demonstrate their effectiveness in helping support flood operations.

Severe Weather:

Ken Waters. National Weather Service - Phoenix. *National Weather Service severe weather products and services.*

Gary Woodall. National Weather Service - Phoenix. *National Weather Service severe weather warnings and communication. Case study Oct 5th, 2010.*

Sarah Walters. Local News Media. *Communicating severe weather events to the public..*

Tim Brice. (Panelist) National Weather Service – El Paso, TX. *Using Social Media to Send and Receive Weather Information.*

Since its inception, the National Weather Service's number one goal has been to protect lives and property. One of the primary methods of doing so is through the issuance of watches, warnings and advisories. Although advanced automated observations systems are used extensively in NWS forecast office operations, ground truth in the form of reports from the public are invaluable in the warning process. Historically, the vast majority of these "spotter" reports have come into the forecast office via telephone. However, in this day of social networking and mobile phones, it has become clear that local storm reports can just as easily be created, transmitted and received through social media platforms like Twitter or Facebook. In my presentation I will discuss the initial steps the NWS has taken into the social media arena. I will discuss the advantages and disadvantages of sending and receiving weather information via social media and look to the future of the NWS's uses of social media in an operational setting.

Randy Clawson & Kendra Cea. Arizona Public Service. *Severe weather preparation and response.*

Ryan Brown. AZ Department of Emergency Management. *ADEM Preparation & Response to Severe Weather*.

Panel Discussion: Woodall, Waters, Brown, Walters, Clawson, Cea, FRs, Brice.

Coffee Break

Deirdre M. Kann, J. Brent Wachter, and Kenneth Widelski NWS Albuquerque NM. *The New Mexico Wildfire Season of 2011: An Extreme Period Requiring a Modified Approach to Decision Support.*

On Sunday, June 26, 2011, high winds forced a tree into power lines igniting a fire that would grow over 3000 acres. By following day, the Las Conchas fire exceeded 40,000 acres and the town of Los Alamos was evacuated. Over the course of four days, extreme growth continued and the fire became the largest recorded wildfire in New Mexico. One month later, the fire was over 150,000 acres and 95% contained. While the growth of this fire could be considered unprecedented, in many respects it was months in the making. In October of 2010, a NOAA press release advertised "another winter of extremes" as a La Niña event strengthened in the eastern Pacific. Historically, much of New Mexico averages only 50% of normal spring precipitation during strong La Niña events and a dry spring with potentially high fire danger was anticipated. However, by early June most of the state was dominated by severe to exceptional drought as New Mexico's driest calendar year on record was underway. Dry conditions were exacerbated by numerous wind events, supported by unstable conditions that contributed to exceptionally high mixing depths. Numerous, large fires made the 2011 spring fire season the worst in recent years. This paper will first describe how the Las Conchas fire developed under near perfect conditions for extreme fire growth. As the event rapidly reached historic levels, operations at NWS Albuquerque evolved to accommodate the elevated level of decision support. Air quality and smoke plumes became a new focus of operations and our customer base, as well as our media requests, expanded dramatically. This proactive transition to new and updated products and services as well as our evolving relationship with a wide range of partners will also be described.

Mike Hardiman. National Weather Service - El Paso, TX. *"Poor Man's Mesonet" – The Value of Supplemental Surface Datasets in NWS Operations.*

For the past few years, a significant effort has been made to seek out sources of supplemental

surface data within the El Paso/Santa Teresa County Warning and Forecast Area (CWFA). Sources include data from networks provided by MADIS (Meteorological Assimilation Data Ingest System), MesoWest, as well as several "Personal Weather Stations" and other surface stations available on networks not currently carried by MADIS or MesoWest. The data has been used for the creation of "Observation Grids" for population into the Graphical Forecast Editor (GFE) system, with future plans for forecast verification and model "bias-adjustments."
Several custom data plots have been created, above the AWIPS baseline, to readily inform forecasters of information critical to warning verification, including peak wind gusts, and rainfall amounts. Rainfall data has proven very helpful in estimating the degree of bias in radar precipitation estimates.
Examples of data plots, and their use, will be shown, as well as limitations in the methods of delivery, and suggestions for improvement. Several regional data networks not currently hosted by MADIS or MesoWest will be presented, particularly over otherwise data-void regions of Mexico. Cooperation will be encouraged to direct a renewed effort to ensure that as many of these data networks are redistributed through MesoWest or MADIS as is possible.

Todd Shoemake. - National Weather Service, Albuquerque, NM. *High Terrain Supercell within a Mid-Tropospheric Ridge*.

Supercell thunderstorms are rarely documented over the high terrain of the southwestern United States, including north central New Mexico. However, on 02 October 2010 a robust and destructive right-moving supercell was observed within the presence of a mid tropospheric ridge. Initial genesis of the thunderstorm updraft occurred over the southeastern foothills of the Jemez Mountains at an elevation of 5.9 kft (1798 m) MSL. The storm propagated southward over elevations varying from 5.1 to 7.59 kft (1554 to 2313 m) MSL within a corridor surrounded by higher mountain peaks of 8 to 10 kft MSL. Once the storm matured, it exhibited supercellular characteristics for two and a half hours along a 50 mile long path extending south from the foothills of the Jemez Mountains. This path continued south over the Rio Grande valley, between the Sandia and San Pedro Mountains, and finally into the foothills of the Manzano mountains. While northern New Mexico is not densely populated, societal impacts were extensive as the supercell crossed two interstate highways, and produced a swath of damaging winds and large hail.
Certainly several challenges arise for operational meteorologists issuing short term forecasts and warning products for severe convective events involving high terrain supercells. The scarce documentation and rarity of these events leaves many operational meteorologists unfamiliar with the regimes that can be conducive to these types of events. This event was complicated further by the presence of the mid tropospheric ridge, a synoptic feature not typically associated with most supercells. Documenting the specifics of this event will prove beneficial to operational meteorologists encountering these rare, but severe events. Several meteorological variables associated with this event will be reviewed, including not only the constructive elements, but also other parameters that may have inhibited the further growth and prolongation of the storm. This lone supercell was the only of its kind on this date in north central New Mexico, and any factors that limited the outbreak of more similar supercells in the region would also supplement the knowledge base of operational forecasters.
The overall storm environment will be presented, including an in-depth look at the synoptic and mesoscale features that were in place over north central New Mexico on 02 October 2010. The

observed thermodynamic and kinematic parameters will also be presented, and these values will be compared to environments that have been empirically shown to support supercell development, namely those associated with the more traditional supercells over the lower elevation plains of the continental United States. Base radar products will also be included along with any similarities or alterations to previously established conceptual models of supercells. The observed supercell motion will also be scrutinized and compared to a recent forecasting tool, the Bunkers Internal Dynamics method, where supercell motion can be forecasted by determining the mean layer wind and bulk shear from nearby hodographs. The effectiveness of this method will be evaluated in this high terrain scenario.

William Cassell and Christopher L. Castro. University of Arizona. *Simulation of Mesoscale Convective Systems during the North American Monsoon Experiment and their Sensitivity to Initial Data Specification.*

A major portion of monsoonal precipitation in the southwest occurs during strong convection events – namely mesoscale convective systems (MCSs). In order to correctly model MCSs, a high resolution model without cumulus parameterization must be used. The North American Monsoon Experiment (NAME) from the summer of 2004 attempted to improve the physical understanding of mesoscale meteorological phenomena associated with monsoon precipitation and to improve short-term numerical weather prediction forecasts. Within the campaign there were a series of intensive observing periods (IOPs) that targeted specific meteorological features of importance, mainly related to the development of organized convective thunderstorms. In this, we conduct high resolution numerical weather-type simulations of several NAME IOPs using the Weather Forecast and Research (WRF) model. In our model configuration, WRF is able to represent most of the salient features of MCSs, including squall lines, gust fronts, and stratiform precipitation. A new adjoint model in WRF is then applied to these cases to determine the sensitivity of model simulations of IOPs to the specification of initial conditions. Adjoint sensitivity analyses indicate that there is a high sensitivity to the specification of low-level moisture and winds in the Gulf of California related to gulf surges and the positioning and strength of upper-level disturbances.

Patrick Broxton, Peter Troch, Michael Schaffner, Carl Unkrich, and Dave Goodrich. University of Arizona. *Development of a Distributed All-Season Flash-Flood Forecasting System.*

In the United States, flash floods kill more people annually than any other type of natural disaster, though despite the importance of predicting such floods, modeling them is still a major challenge. Many of the operational tools available to address and forecast flash floods have shortcomings such as inadequate spatial and temporal resolutions and missing formulations for snow and snowmelt. The current research is aimed at broadening the applicability of flash flood modeling. We design and implement a system that combines a distributed flood model, the Kinematic Runoff and Erosion model (KINEROS), with a distributed subsurface flow model and an energy balance snow model. The combined model system, which is tested in humid and semi-arid watersheds in Delaware County, New York, and near Tucson, Arizona, is spatially distributed and has a temporal resolution of five minutes during events. It uses readily available data sources for calibration and real-time operation. We believe that this system will make a meaningful contribution to the flash-flood forecasting community especially because it has very high spatial and temporal resolutions, and its ability to run in continuous mode allows for improved consistency of flash flood predictions.

Thang Luong, Christopher L. Castro, and William Cassell. University of Arizona.
Improvement in the representation of warm season convective precipitation in complex terrain using a Modified Kain-Fritsch convective parameterization scheme.

A modified Kain-Fritsch convective parameterization scheme (CPS) has been written for Regional Atmospheric Modeling System (RAMS) that includes a new diagnostic equation to compute updraft velocity, closure assumption, and trigger function. These modifications take the vertical gradient of the pressure perturbation into account, making the scheme more appropriate for use in complex terrain. In the original test case of the modified scheme for a flash flood event in Vietnam, the regional model produced larger and deeper strati-form clouds that lead to a higher amount of resolvable precipitation.
We have recently implemented the modified KF scheme into WRF to simulate the North American Monsoon events in the Southwest. High-resolution experiments of Intensive Observing Periods (IOP) during the North American Monsoon Experiment (NAME), using a multiple grid nesting strategy, show that modified scheme produces a stronger initial updraft and enhances mesoscale convective system development and propagation. Therefore the modified CPS is not only improves the regional model representation of precipitation in the coarse domain (10 km) on which it is activated, but also on the finest domain where the convection is explicitly represented. We also show similar results considering regional climate model simulations used to simulate the North American Monsoon.

Ron Holle. *Lightning frequencies and casualties in the Southwest U.S.*

Cloud-to-ground lightning maps by month for the United States. have been developed from 1996 through 2007. National Lightning Detection Network data are used to show both the density of cloud-to-ground lightning per month, and the monthly percentage of the year's total. Over many areas of the southwest, a major change occurs from minimal lightning in June to high frequencies in July, somewhat less in August, and less in September except in the far southwest areas of the region. This southwest U.S. change from June to July is one of the largest month-to-month gradients in the country. Comparison will also be made briefly with the new Global Lightning Dataset GLD360 over North America.

Lightning fatalities in the U.S. over the last decade show that the Northern Rockies rivals the southeastern states for the highest ranking of fatalities per million people, and that lightning fatality rates in the southern Rockies are also elevated above some other regions of the country. The diverse range of activities and locations of lightning casualties will also be described with a detailed compilation of Arizona lightning casualties in the last few decades.